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Study on Heavy Ion Microbeam and Single Ion Hit

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In TIARA facility of JAERI Takasaki, the author studied on beam optics, beam measurement and control for microbeam systems. While local elemental analysis by microbeams observing secondary emission from samples is one of major applications, studying and utilizing local radiation damage in local area of samples are other important applications. In the former case, microbeam should be non-destructive to samples, but in the later, that is accepted as a destructive tool to samples. The author developed a heavy ion microbeam system for the later purpose, and introduced a single ion hit system, in order to irradiate a sample by single ions with the spatial resolution of less than 1 μm.

A schematic diagram of the system is shown in Fig. 1. Single ion hits can be

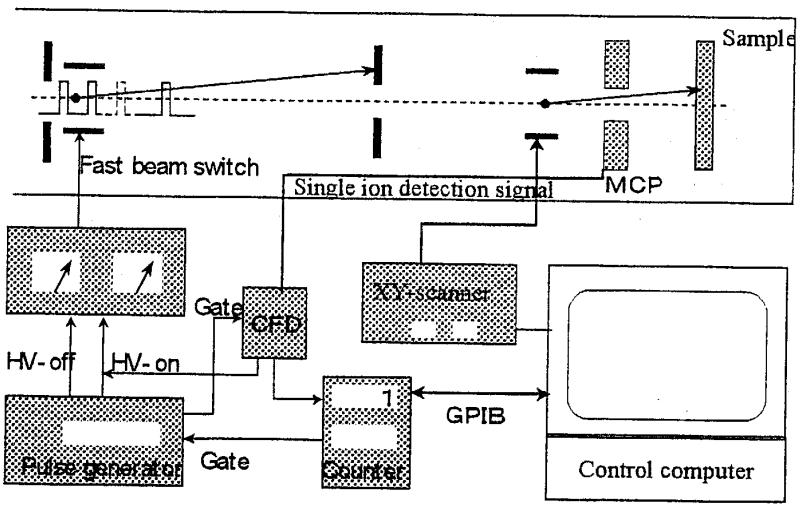

Fig. 1 Schematic diagram of the single-ion-hit system consisting of a single ion detection and a fast beam switch system

controlled by an efficient single ion detection using an annular type micro-channel plate (MCP) assembly and by a fast beam switch generating beam pulses which also act as gate signals to minimize the error due to spurious pulses from the MCP in single ion detection. In order to demonstrate the performance of this system, a programmed 'daruma' dot pattern as shown in Fig. 2 (a) was written into a 200 x 200 μm^2 area of a CR-39 plate using 15 MeV Ni ions microbeams. Figure 2 (b) shows etch pits at hit positions formed by single ions (one ion per point) followed by chemical etching with 60 °C, 6 N (normal) NaOH solution for half an hour.

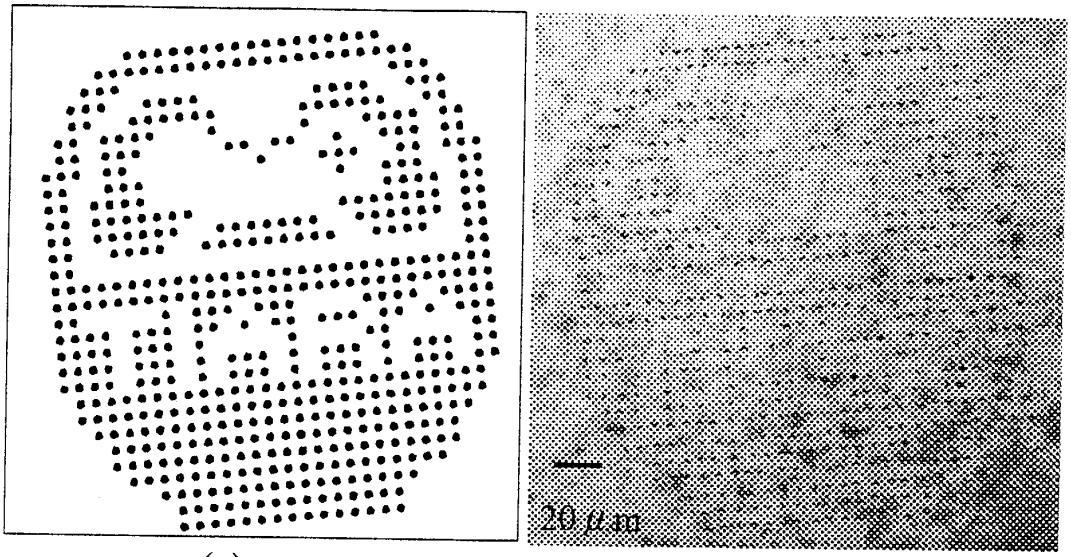

Fig. 2 Single ion irradiation experiment as a demonstration of the system. (a) a programmed 'daruma' dot pattern to be written in a 200 x 200 μm^2 area. (b) an etch pit pattern formed by single-ion (15 MeV Ni) hits with 1 hit/dot.

The heavy ion microbeam system combined with the single-ion-hit is a powerful tool to reveal the mechanism of radiation effects caused by single ions at specific local area of samples, such as single event upset phenomena in semiconductor devices for spacecraft.